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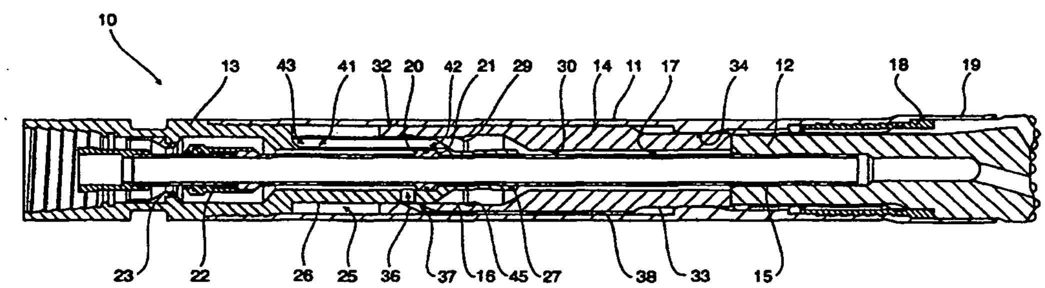

(57) Abstract

This specification relates to a percussive hammer, and in particular to a piston working in conjunction with a spigot for controlling air flow to the piston. The invention comprises a hammer barrel (11) that is adapted for connection at its upper end to a source of high pressure fluid, a drill bit (12) held in the lower end of the hammer barrel (11), a spigot (25) located in and extending axially within the hammer barrel (11) for control of the high pressure fluid, and a piston (14) slidably located within the hammer barrel (11) so that it is able to reciprocate between the spigot (25) and drill bit (12). The upper end of the piston has a bore (16) that co-operates with the spigot (25). The spigot (25) has an opening (36) and the piston (14) has a transfer port (37) which directs air flow around the piston (14). The spigot (25) in combination with the bore (16) forms a sealed chamber which is used to force the piston (14) downwardly to impact against the drill bit (12). The construction greatly simplifies the assembly of the hammer and results in components which are more easily produced by comparison to currently available percussive hammers.

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A PERCUSSIVE HAMMER DRILL

This invention relates to a percussive hammer drill, and in particular to improvements in the piston and porting design for both a reverse circulation hammer and a conventional hammer.

Pneumatically driven percussive drilling hammers used in the mining industry are well-known. These hammers are normally located at the end of drilling rods which supply high pressure air to the hammer. A drill bit is inserted at the end of the hammer and the hammer contains a piston which reciprocates back and forth and impacts against the impact end of the drill bit to provide the percussive force which allows the drill bit to fracture rock and thereby drill a hole into the rock.

There are conventionally two piston cylinder chambers formed at either end of the reciprocating piston and the inner surface of a hammer. Some hammers use a barrel liner. The high pressure supply air is supplied alternately into these piston chambers to force the piston in either direction. Supply air is normally supplied via a manifold or a liner which has apertures which align with transfer ports within the piston that direct high pressure air into the required piston chamber to thereby cause reciprocating motion. The piston is accelerated towards the drill bit, and strikes it before moving upwardly.

There are two types of commonly used percussive hammers. The first is known as a conventional percussive hammer where the supply air is supplied through the hammer and exhausted via apertures in the bit with the air returning to the surface between the hole that is being drilled and the outer surface of the hammer and attached drill tube. The other type of percussive hammer is known as a reverse circulation hammer where the supply air exits the hammer around the peripheral outer edge of the drill bit whereupon the air is directed across the cutting face and up through central apertures in the drill bit and into a central sample return tube that extends from the drill bit

through the hammer and through each of the drill rods. Both types of hammers are well-known.

Common problems between both types of hammers are as follows:

1. The need for careful assembly between various components that are assembled axially in series or in parallel to ensure that all parts of the assembly remain under the required axial load, while at the same time ensuring correct alignment of supply and transfer ports between the manifold and the piston. This normally requires the use of shims or flexible elements between various components to ensure accurate assembly.

2. The use of fixed supply ports which causes the supply fluid to be admitted to the first piston chamber early, and therefore the piston begins decelerating before striking the impact end of the bit. This results in diminished strike energy. In addition, fixed supply ports limit the magnitude of the exhaust pressure with which the hammer can operate (as in the case of a deep hole which is flooded with water) because the stroke of the piston will diminish to the point where the supply port will not open sufficiently.

3. The use of separate moving valve components, which move between hard stops that are fixed in the hammer. They are necessarily large to span the stroke of the piston and they result in an unnecessary increase in the length of the hammer and also have the effect of reducing the maximum piston area for a given diameter hammer. In addition, separate moving valve components move between hard stops which are fixed in the hammer and prone to sticking as a result of dirt particles locating between the sliding surfaces of the valve.

4. Reverse circulation hammers use divided sample return tubes which generally have end flanges that are of a much greater diameter by comparison to the

sample tube. This requires either fabrication of the component or the wastage of material by machining the sample tube and flange from a large diameter blank.

5. In conventional hammers, air or fluid has to pass around the check valve which is located in its own separate passageway. This obviously takes a significant amount of space within the hammer as it is located behind the piston where it will add to the overall length, weight and cost of the hammer.

6. Reverse circulation hammers usually make use of a liner which is located inside the hammer barrel. The use of a liner reduces the maximum possible diameter of the piston, which in turn reduces the impact energy that the piston can provide.

7. A problem with both types of hammers is the need to drill very long holes in the piston that are angled with respect to its longitudinal axis which allow connection of the two piston chambers with the high pressure supply of air. These holes are very long, and therefore difficult and time consuming to drill. The holes can also weaken the piston significantly which will reduce the durability and life of the piston.

8. It is sometimes necessary to prevent rotation of various components with respect to the air supply ports to ensure adequate alignment of the various supply and transfer passageways.

9. It is often necessary to reduce the outside diameter of the piston behind its drill bit impact face to provide a flushing passage. This reduction in piston diameter can weaken the piston in an area of high stress.

10. There is often a problem in providing adequate exhaust passages in a reverse circulation hammer. In the normal operation of a reverse circulation hammer, exhaust air must pass between the impact faces of both the piston and the drill bit. Obviously, there is a significant restriction to the flow of air when the piston

and drill bit are closely spaced or totally closed off when impact occurs which of course will prevent flow of exhaust air. This problem is normally overcome by providing radial channels across either one or both of the impact faces. However, this has the effect of significantly weakening these particular components.

It is an object of this invention to overcome the abovementioned problems, and to provide a hammer design which is simple to produce and use and that provides a useful alternative to existing hammers.

In its broadest form, the invention is a percussive hammer comprising:

a hammer barrel adapted for connection at its upper end to a high pressure fluid supply,

a drill bit held in the lower end of said hammer barrel,

a spigot located in, and extending axially within, said hammer barrel for control of said high pressure fluid,

a piston slidably located within said hammer barrel so that it is able to reciprocate between said spigot and said drill bit, at least the upper end of said piston in sealing engagement with said hammer barrel,

a bore within the upper end of said piston within which said spigot locates, said bore shaped so that a sealed chamber is created between said spigot and piston that is intermediate the ends of said spigot when said piston is in its upper position,

at least one fluid conduit that extends from said aperture in the piston to the lower end of said piston,

at least one fluid outlet on said spigot for supply of said high pressure fluid to said piston, and

at least one transfer port extending from the surface of said bore to the outer surface of said piston, said outlet and transfer port positioned so that

(i) as said piston reaches its lower position, said at least one transfer port aligns with said at least one outlet so that high pressure fluid flows between said piston and hammer barrel below said sealed end and acts to force said piston upwardly, and

(ii) as said piston reaches its upper position, said at least one outlet opens within said sealed chamber to allow flow of high pressure fluid therein to force downward movement of said piston.

Preferably, the spigot has two spaced sealing surfaces that engage the inner surface of the tubular piston to form a seal. The region of either or both the spigot and the piston between the two sealing surfaces may be shaped to form the second piston chamber. The spigot may be formed on the end of a conventional manifold.

The hammer may be provided with a further piston chamber which is formed between the hammer barrel and the spigot between which the upper tubular end of the piston locates with both the inner and outer surfaces of the tubular end of the piston sealing against the spigot and the hammer barrel respectively. In this form of the invention, the spigot may be provided with second porting means that, when the piston is in its top position with the opening allowing fluid flow into the second piston chamber, provides a connecting passage to allow high pressure fluid to flow into the third piston chamber via this second port means in the spigot. This provides further surface area in addition to that provided in the second piston chamber against which the high pressure fluid can act to force the piston down towards the drill bit.

The abovedescribed configurations of the invention are suitable for use with either a conventional normal circulation percussion hammer or a reverse circulation hammer. The only difference is that in a reverse circulation hammer, a central sample tube extends from the end of the drill bit through the piston and spigot.

In another aspect of the invention, an exhaust bypass passage is provided for use with a reverse circulation hammer. This exhaust bypass passage extends from adjacent the impact end of the drill bit through the drill bit wall to a point on the outer periphery of the drill bit or to any other part of the drill bit as required. This enables air to exhaust which might otherwise be prevented from doing so when the piston is closely spaced or touching the impact face of the drill bit. The exhaust air instead is able to enter the

bypass passage to in turn find its way to the exhaust passage between the drive sub-assembly and drill bit.

The aperture within which the sample tube locates in the rear of the drill bit may be chamfered with the opening of the bypass passage being located within the chamfered portion. The bypass passage may comprise a short diagonal hole, and may also comprise a number of radially spaced passages.

In order to fully understand all of the features of the invention, preferred embodiments will now be described. However, it is to be realised that the invention is not to be confined or restricted to the precise features of the embodiments.

These embodiments are illustrated in the accompanying drawings in which:
Fig 1 shows a cross-sectional view of a reverse circulation hammer with the piston in its lower position,
Fig 2 shows a cross-sectional view of a reverse circulation hammer with the piston in its lower position and with bypass passages in the drill bit,
Fig 3 shows a part enlarged view of Fig 1,
Fig 4 shows a cross-section of the spigot at line 4-4,
Fig 5 shows a part enlarged view of Fig 1,
Fig 6 shows a cross-section of the piston and hammer barrel at line 6-6,
Fig 7 shows a part enlarged view of Fig 2,
Fig 8 shows a part enlarged view of Fig 2 with the piston in its upper position,
Fig 9 shows a cross-sectional view of the reverse circulation hammer shown in Fig 1 with the drill bit and piston in a reaching position,
Figs 10 to 13 show a part cross-sectional view of reverse circulation with a two position valve in the piston,
Fig 14 shows a part cross-sectional view of a hammer and conical strainer,
Fig 15 shows a cross-sectional view of a normal circulation hammer with the piston in its lower position,

Fig 16 shows an enlarged part cross-section view of Fig 15,

Fig 17 shows a cross-section of the spigot at line 17-17,

Fig 18 shows an enlarged part cross-section view of Fig 15,

Fig 19 shows a cross-section of the piston and barrel at line 19-19

Fig 20 shows a perspective view of a piston, and

Fig 21 shows a perspective view of a spigot.

Referring to Fig 1, the reverse circulation hammer 10 comprises a hammer barrel 11 with a drill bit 12 located at its lower end, and a manifold 13 located in its upper end. A piston 14 is located between the drill bit 12 and the manifold 13, and a sample tube 15 extends from the drill bit 12 and through the manifold 13.

The drill bit 12 has a splined shank that engages with corresponding splines in a drive sub 18. The drive sub 18 is threadably engaged in the end of the hammer barrel 11. Located between the end of the hammer barrel and the drive sub 18 is a shroud 19 that assists in directing exhaust air towards the cutting face of the drill bit 12.

The sample tube 15 has a circular ridge 20 which abuts against a shoulder 21 in the manifold 13. The supply air pressure acts against the circular ridge which assists in holding the sample tube 15 in the hammer 10. A check valve 22 is attached to the sample tube 15, and the manifold has a check valve seat 23 against which the check valve 22 may locate. The check valve 22 is spring-loaded, and opens upon high pressure fluid being applied to the manifold 13.

The piston 14 is substantially tubular and has outer surfaces that engage against the hammer barrel 11 to form seals and has a bore 16 at its upper end that has inner surfaces which engage against various portions of the spigot 25 to form a seal. A fluid conduit 17 extends from the end of the bore 16 to the end of the piston 14. The manifold 13 has a spigot 25 that is shaped so that it can engage axially within the bore 16 in the upper end of the piston 14. The upper part of the conduit 17 also forms part of the bore within which the spigot 25 locates.

The spigot 25 of the manifold 13 has an upper sealing surface 26 and a forward sealing surface 27. A length of the end of the spigot 25 has a smaller diameter than the upper section of the spigot 25. The upper sealing surface 26 is on the upper section of the spigot 25 and the forward sealing surface is on the end of the spigot 25. The upper sealing surface 26 of the spigot 25 is engaged by the upper inner surface 29 of the bore 16 in the upper end of piston 14. The forward sealing surface 27 of the spigot 25 is engaged by the inner surface 30 of the conduit 17 which has a smaller diameter than the upper inner surface 29. The upper inner surface 29 comprises a first diameter of the bore 16, and the inner surface 30 comprises a second diameter of the bore 16 which is smaller than the first diameter. The upper outer surface 32 of the piston 14 engages with the inner surface of the hammer barrel 11. The lower end of the piston 14 has a smaller diameter by comparison to the remainder of the piston 14 and has a lower outer surface 33 that engages with inner surface 34 of the hammer barrel 11.

The spigot 25 of the manifold 13 has a number of openings 36 that allow transfer of high pressure fluid from the manifold 13. The piston 14 has a plurality of transfer ports 37 and transfer channels 38 that are aligned with each of the transfer ports 37.

A first piston chamber is formed between the seal at the upper outer surface 32 of the piston 14 and the lower outer surface 33 of the piston 14. The fluid used in the embodiments described is high pressure air, and as seen in Fig 3, supply air is able to enter the manifold 13 and pass through the annulus formed between the inner surface of the manifold 13 and the sample tube 15 to the openings 36. With the piston 14 in its lower position, the transfer ports 37 align with the openings 36. A radial channel 40 is formed on the upper inner surface 29 of the piston 14 in the vicinity of the entrance to the transfer ports 37. This ensures free air flow from the openings 36 through the transfer ports 37 regardless of the axial position of the piston 14. In other words, the piston 14 is free to rotate with respect to the manifold 13 without disrupting the air flow.

With the piston 14 in its bottom position and with the openings 36 aligned with the transfer ports 37, high pressure air is able to flow into the first piston chamber via transfer ports and channels 37 & 38. This acts to force the piston 14 upwardly. The transfer ports 37 remain aligned with the openings 36 long enough to provide sufficient supply of pressurised air to accelerate the piston into its upper position. The openings 36 close before the end of the piston stroke to allow for exhaust channels to open and to allow for expansion of the air against the piston 14 to gain maximum power from the expansion of the high pressure air.

In addition to the openings 36, the spigot 25 of the manifold 13 has a series of second ports 41. The second ports 41 extend between opening 42 and opening 43. The second ports 41 provide a conduit or connecting passage to a sealed chamber, that in this embodiment is a second piston chamber that is formed between the upper and forward sealing surfaces 26 and 27 (when in engagement with the upper and inner surfaces 29 and 30 of the piston 14) and a third piston chamber that is formed between the upper sealing surface 26 of the spigot 25 and the inner surface of the hammer barrel. The third piston chamber is sealed by the upper end of the piston 14.

When the piston 14 is in its upper position as illustrated in Fig 8 the openings 36 are able to supply high pressure air into both the second and third piston chambers. A shoulder 45 defines the end of the upper inner surface 29 of the piston 14, and beyond the shoulder 45 the diameter of the bore 16 enlarges in diameter to provide an airflow passage from the openings 36 into the second position chamber. As seen in Fig 8, the upper and forward sealing surfaces 26 and 27 of the spigot engage with their respective surfaces of the piston 14 thereby defining the sealed second piston chamber.

The high pressure air which is flowing into a second piston chamber is able to flow through openings 42 into the second ports 41 and out of the openings 43 into the third piston chamber. The effective area of the piston 14 exposed in the third piston chamber is added to the effected area of the portion of the piston exposed in the second piston

chamber. The total piston area against which the high pressure supply acts is not significantly reduced by the presence of the manifold 13 or the spigot 25.

The high pressure air in both the second and third piston chambers accelerates the piston 14 downwardly so that the end of the piston 46 strikes against the end of the drill bit 47.

As can be seen in Fig 3, with the piston 14 in its lowermost position, there is a clear channel from the third piston chamber that will allow airflow through the second ports 41 and into the second piston chamber and from there into the conduit 17. When the piston 14 is in its lowermost position, the forward sealing surface 27 of the spigot 25 does not engage with the inner surface 30 of the piston 14. This provides a pathway for exhaust air to flow through the conduit 17 and out of the lower end of the piston 14. A flow of exhaust air will occur in this manner as the piston travels towards its lower position. Obviously, the high pressure air which is released into the second and third piston chambers will expand rapidly to exhaust as soon as the forward sealing surface 27 disengages from the inner surface 30. Likewise, as seen in Fig 8, the high pressure air supply to the first piston chamber will exhaust when the lower outer surface 33 disengages the inner surface 34 of the hammer barrel 11.

Figs 2, 7, 8 & 10 show exhaust bypass passages 50 in the drill bit 12. The exhaust air from the piston is preferably channelled between the outer surface of the drill bit 12 and the hammer barrel 11. The air is then able to exhaust past the shroud 19 towards the cutting face of the drill bit 12. However, when the piston is at its bottom position, with the ends 46 and 47 of the piston and drill bit abutting or close, exhaust bypass passages 50 provide an alternate means towards the outer surface of the drill bit 12. As illustrated in Fig 7, exhaust air travelling between the sample tube 15 and the inner tube of the piston 14 would need to travel between the ends of the piston and drill bit 46 and 47 in order to exhaust from the end of the hammer 10 without the bypass passage 50. It is normal practice to provide slots or other channels between these two surfaces in order to allow the exhaust air to flow. However, this represents a significant restriction to

flow, and therefore decreased performance of the hammer. Channels on the impact face reduce impact area with a resultant increase in the stress applied to the bit and piston.

Fig 9 shows the drill bit 12 in a reaching position and the piston in its lowermost position. In this configuration, the high pressure supply air can be used to flush both the hammer and hole being drilled. The supply air is able to flow from the openings 36 past the upper end of the piston 14 into the second ports 41 via opening 43 into the second piston chamber via openings 42 through the conduit 17 and to exhaust via the opening between the forwarding sealing surface 27 and the spigot 25 and the inner surface 30. The air continues to flow past the piston 14 and exhaust from the end of the hammer 10. The hammer 10 will continue to flush for as long as the drill bit 12 is in its reaching position. By pushing the hammer 10 down in the hole, the drill bit 12 will be forced back into the hammer, will abut against the end of the piston 14 and will continue to push the piston 14 upwardly until the openings 36 align with the transfer ports 37. When this occurs, the piston will be accelerated into its upper position.

Obviously, the piston 14 will operate in a reciprocating motion. When forced towards its lowermost position, the piston 14 impacts against the end of the drill bit 12. When forced towards its upper position, the upward movement of piston 14 is arrested as the openings 36 open into the second and third piston chambers which force the piston 14 into its downward motion.

Figs 10 to 13 illustrate the same reverse circulation hammer shown in Figs 1 and 2 but with the addition of a valve 52. As seen in Figs 10 to 13, the valve 52 is a tubular member that locates within a recess 53 on the upper inner surface 29 of the piston 14. The valve 52 is held captive between the piston 14 and the spigot 25 of the manifold 13.

The valve 52 is designed to slide between stops formed by base shoulder 54 and a valve retainer ring 55. The valve retainer ring 55 is held in place by a circlip 56 and prevented from rotation by an indexing ball 57. The indexing ball locates within a notch formed on the outer periphery of the valve retainer 55. The valve retainer ring 55 has a castellated

end which are aligned with the transfer ports 37 by the indexing ball 57 to enable airflow. The use of a castellated edge together with an increased internal diameter of the castellated portion means that accurate alignment with the openings 36 to ensure free airflow is not required. The castellated end of the valve retainer 55 provides a hard stop for the valve 52 which is used to push the valve 52 down with piston 14.

The valve 52 slides between two positions to partially close off and open the openings 36. This has the effect of delaying entry of the high pressure supply air into the first piston chamber for as long as possible during the forward stroke. Premature entry of high pressure air into the first piston chamber would have the effect of reducing the impact force of the piston 14 against the drill bit 12. By delaying this for as long as possible, the impact force is maximised.

The valve 52 movement lags the piston 14 movement. When the valve 52 expose the openings 36 on one side, the valve 52 is forced to open further by the action of high pressure air on the valve 52. If the valve 52 sticks, it is likely to be jolted free through the effects of impact of the piston 14 on the drill bit 12. In addition, the change of direction at the end of the rearward stroke would also provide a jolting force which would free a stuck valve 52.

As seen in Fig 10, the piston 14 is just impacting the end of the drill bit 12. The openings 36 have only just come into alignment with the transfer ports 37. In this position, the valve 52 will be forced to move forward to the position shown in Fig 11. In this position, the transfer port 37 is fully open, and the piston 14 can then be forced back towards its upper position. This is shown in Fig 12 where supply air is shown entering the second piston chamber. This in turn forces the piston 14 to travel in its downward direction. When this occurs, the piston 14 moves, while the valve 52 remains stationary so that the valve 52 again partially covers the transfer ports 37. This will result in delayed transfer of high pressure supply air through the transfer ports 37.

Fig 14 shows a combined strainer and sample tube retainer 58. It is also designed to act as a sample tube adaptor to enable connection of the sample tube to the following drill rod or pipe. The portion with the strainer holes 59 therein is conical which assists in easy cleaning by accessing the strainer from the rear. A seal 61 is provided to locate against the sample tube 15, and a radial flange 66 centralises the strainer. The radial flange 66 may also be used as a strainer with apertures therein or it may have large apertures to enable cleaning of the strainer surface from behind. A retaining clip 67 holds the strainer in place.

Figs 15 to 19 illustrate a normal circulation percussion hammer. The design and operation of the piston 14 are substantially identical to the reverse circulation hammer illustrated in Figs 1 to 13. However, in the normal circulation hammer, the air exhausts through the conduit 17 which extends through the centre of the piston 14 through the drill bit 12 and out through the base of the drill bit via apertures 60. With this arrangement, the sample tube 15 is not used, as the exhaust air and debris returns to the surface between the hammer and drill string and the hole being drilled. Apart from this major difference, the remaining components of the hammer operate in much a similar way as is illustrated in the remaining drawings.

A strainer 62 shown in Fig 16. The strainer has a plurality of first apertures 63 through which supply air passes. The air then moves apertures 64 and into the spigot 25 of the manifold 13. The strainer 62 has the advantage of being easily cleaned from the end of the hammer 10, and can be easily withdrawn from the hammer by release of circlip 65.

The forward or bottom end of the strainer 62 is also used as the seat for the check valve. The check valve 70 is located adjacent to the openings 36. When it is opened by the passage of supply air, the check valve is pushed forwards or downwardly to allow air to pass into the openings 36. The air does not have to pass around the check valve 70 and accordingly considerable space is saved in the hammer. The check valve 70 is also shown with an optional choke feature to provide additional supply air from the hammer for clearing water and cuttings from the hole when air or fluid exhausting

from the hammer provides insufficient flow for this purpose. It consists of one or more radial holes 72 forward of the sealing surface of the check valve 70 which connect to an axial hole 73 that pass through to the end of the spigot 25. If the choke is not needed or the size needs to be changed, then the check valve 70 can be changed for one which has no radial holes or has different sized radial holes 72.

Flushing of the hammer with the drill bit 12 in its reaching position is again similar to that described for the reverse circulation hammer.

A valve 52 in the same as that illustrated in Figs 10 to 13 can be used in a normal circulation hammer. Again, the operation of the valve 52 is identical to the operation described for the reverse circulation hammer.

As can be seen from the descriptions of the above embodiments, both the reverse circulation and normal circulation hammer have several unique advantages. They are as follows:

1. The fact that no shims or flexible elements are required between the various components in the assembly.
2. Simple short transfer ports are used in the piston to control airflow. This avoids the use of long narrow transfer holes which are harder to make, and weaken the piston.
3. The manifold does not require precise rotational alignment about its central axis in respect of its air passages by comparison to prior art hammers. In addition, there is no need for alignment of the piston about its longitudinal axis for correct operation.
4. The strainers in both hammers are easily accessed for clearing of debris.
5. The valve member in the end of the piston increases impact energy by delaying the supply air into the first piston chamber. This also increases the range of exhaust pressures that can be used on the hammer by allowing a shorter stroke.
6. The valve member is mounted in the piston and is smaller than a valve that would ordinarily be mounted to the fixed parts of the hammer. It can also be jolted free during normal operation if foreign particles should temporarily jam the valve operation.

In respect of the reverse circulation hammer, it has the following advantages:

1. There is no need for the use of a separate piston liner with the benefit that the piston driving areas can be larger with greater impact energy for the same outsize diameter hammer barrel.
2. The piston and bit impact faces are not interrupted by radial groves to allow the passage of exhaust gases (as is the case with known reverse circulation hammers) which would weaken these parts of the hammer. The invention allows a clear exhaust passage to remain open throughout the operating cycle of the hammer.
3. The sample tube is a single part without the need for large diameter flanges.
4. The sample tube for conveying samples back through the hammer to the surface is made of one piece that is exposed to low axial forces and pressures. This avoids the use of two piece tubes which are flanged, sealed and then clamped together.
5. The sample tube is retained in the hammer by connection with the sample tube adaptor. This means that the sample tube can be easily removed and replaced from the rear of the hammer without disassembling the hammer itself.
6. The sample tube is held in place by the pneumatic forces during normal operation.
7. If connection of the sample tube adaptor fails, then the sample in the following drill pipe will retain all of the component pieces in place.
8. The check valve is mounted on the sample tube near the rear end of the sample tube, and is removed on the sample tube as the sample tube is removed.
9. The check valve seat can be readily removed from the rear of the hammer.
10. The sample tube has a small diameter shoulder which enables the use of smaller diameter stock with less machining.
11. The air which passes through the hammer when the bit is in its reaching position passes around the rear of the piston and forwards through its central hole towards the bit, rather than travelling past the outside front portion of the piston via an otherwise narrow section behind the piston impact base. This arrangement in the prior art hammers weakens the piston.
12. The use of diagonal exhaust bypass passages in the end of the drill bit provides a passage that is constantly open and replaces what is currently used which comprises

small radial grooves on the impact face of the bit which themselves restrict airflow and weaken the highly stressed area of the impact face.

13.The hammer can be readily fitted with an adaptor sub to simplify the adaptation of the hammer to different design drill pipes used by various drillers. The adaptor sub replaces the separate check valves with a readily manufactured, repaired and inspected seat area in the front opening.

The normal circulation hammers have several special features which are as follows:

1. The check valve has an optional integral "choke", which acts a supply air bypass control nozzle arrangement which can be used to dump additional air through the well that is being drilled. This helps clear cuttings and/or water from the hole. The choke is changed by changing the check valve.
2. The first piston chamber which pushes the piston rearwards to its upper position does not depend on an airtight seal between the bit and its drive sub and a "control tube" as is conventionally used with known prior art hammers. The control of prior art hammers is mounted in the rear of the bit and seldom aligns with the hole and the piston when they are separated.
3. The check valve seat and strainer are combined into a single part which is retained by a single circlip in the rear of the hammer.

As will be seen from the above, the hammer described in this specification is a significant improvement by comparison to known percussion hammers.

The claims defining the invention are as follows:

1. A percussive hammer comprising:

a hammer barrel adapted for connection at its upper end to a high pressure fluid supply,

a drill bit held in the lower end of said hammer barrel,

a spigot located in, and extending axially within, said hammer barrel for control of said high pressure fluid,

a piston slidably located within said hammer barrel so that it is able to reciprocate between said spigot and said drill bit, at least the upper end of said piston in sealing engagement with said hammer barrel,

a bore within the upper end of said piston within which said spigot locates, said bore shaped so that a sealed chamber is created between said spigot and piston that is intermediate the ends of said spigot when said piston is in its upper position,

at least one fluid conduit that extends from said aperture in the piston to the lower end of said piston,

at least one fluid outlet on said spigot for supply of said high pressure fluid to said piston, and

at least one transfer port extending from the surface of said bore to the outer surface of said piston, said outlet and transfer port positioned so that

(i) as said piston reaches its lower position, said at least one transfer port aligns with said at least one outlet so that high pressure fluid flows between said piston and hammer barrel below said sealed end and acts to force said piston upwardly, and

(ii) as said piston reaches its upper position, said at least one outlet opens within said sealed chamber to allow flow of high pressure fluid therein to force downward movement of said piston.

2. A percussive hammer according to claim 1 wherein a length of the end of said spigot has a smaller diameter than the upper section of said spigot and said bore comprises a first diameter bore within which said upper section locates and a smaller second diameter bore within which said spigot end locates.

3. A percussive hammer according to claim 2 wherein said at least one outlet is on said upper section of said spigot.

4. A percussive hammer according to either claim 2 or claim 3 wherein said spigot end is clear of said second diameter bore when said piston is in its lower position so that fluid may flow to exhaust through said bore and along said at least one fluid conduit.

5. A percussive hammer according to any one of claims 2, 3 or 4 wherein a seal is formed between a forward end of said spigot and said second diameter bore.

6. A percussive hammer according to claim 5 wherein the outer surface of the upper section of said spigot seals with an upper portion of the inner surface of said first diameter bore.

7. A percussive hammer according to claim 6 wherein said chamber comprises the chamber formed between the seal on said upper section and the end of said spigot, the volume of said chamber increasing as said piston moves from its upper position.

8. A percussive hammer according to either claim 6 or claim 7 wherein the lower portion of said first diameter bore has a larger diameter than the adjacent said upper portion and wherein said at least one outlet opens into said lower portion when said piston is in its upper position.

9. A percussive hammer according to any one of the preceding claims further comprising at least one second port forming a conduit extending longitudinally within said spigot that connects said chamber with the volume above the upper end of said piston.

10. A percussive hammer according to claim 9 wherein a plurality of second ports are radially spaced around said spigot.

11. A percussive hammer according to either claim 9 or claim 10 wherein said second port opens above the upper end of said piston when said piston is in its upper position.

12. A percussive hammer according to any one of the preceding claims wherein high pressure fluid flows through the centre of said spigot and said at least one outlet comprises an aperture in the surface of said spigot.

13. A percussive hammer according to claim 12 comprising a plurality of outlets radially spaced around said spigot, and further comprising a radial channel on the surface of said bore, said at least one transfer port extending from said radial channel.

14. A percussive hammer according to claim 13 comprising a plurality of transfer ports radially spaced around said piston.

15. A percussive hammer according to any one of the preceding claims wherein the lower end of said piston seals with a portion of said hammer barrel when said piston is in its lower position, and that said seal at the lower end of the piston is maintained for a portion of the upward movement of said piston.

16. A percussive hammer according to claim 15 further comprising at least one channel extending longitudinally in the outer surface of said piston from said transfer port or ports to the lower end of said piston.

17. A percussive hammer according to any one of the preceding claims wherein exhaust fluid from the end of said piston flows through the centre of said drill bit to the cutting face of said drill bit and to the surface between said hammer and the hole being drilled.

18. A percussive hammer according to any one of claims 1 to 16 further comprising a sample tube extending through said spigot, piston and connecting to the end of said drill bit, said at least one fluid conduit comprising the annular space between the outer surface of said sample tube and said piston, said fluid exhausting from the end of said piston being directed around the outer surface of said drill bit, across the drill bit cutting face and back to the surface via said sample tube.

19. A percussive hammer according to claim 18 further comprising at least one passage from the centre of said drill bit to the outer surface of said drill bit that allows exhaust fluid to flow to the outer surface of said drill bit when said piston is in contact or close to the impact end of said drill bit.

20. A percussive hammer according to any one of the preceding claims further comprising a sliding valve element that is held between said spigot and said bore that slides between two positions wherein in one position it partly closes said transfer port or ports so that the flow of high pressure fluid into said transfer port or ports is delayed, and then moves to a second position where said transfer port or ports are fully open when said piston is in its lower position.

21. A percussive hammer as herein before described with reference to and as illustrated in the accompanying drawings.

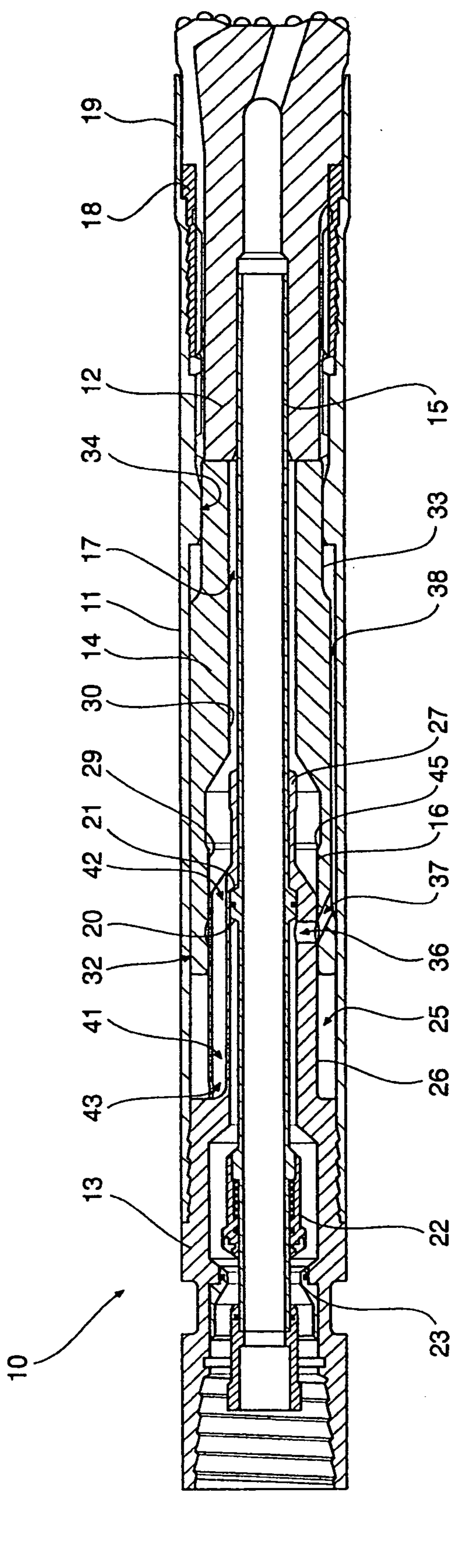
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FIG 1

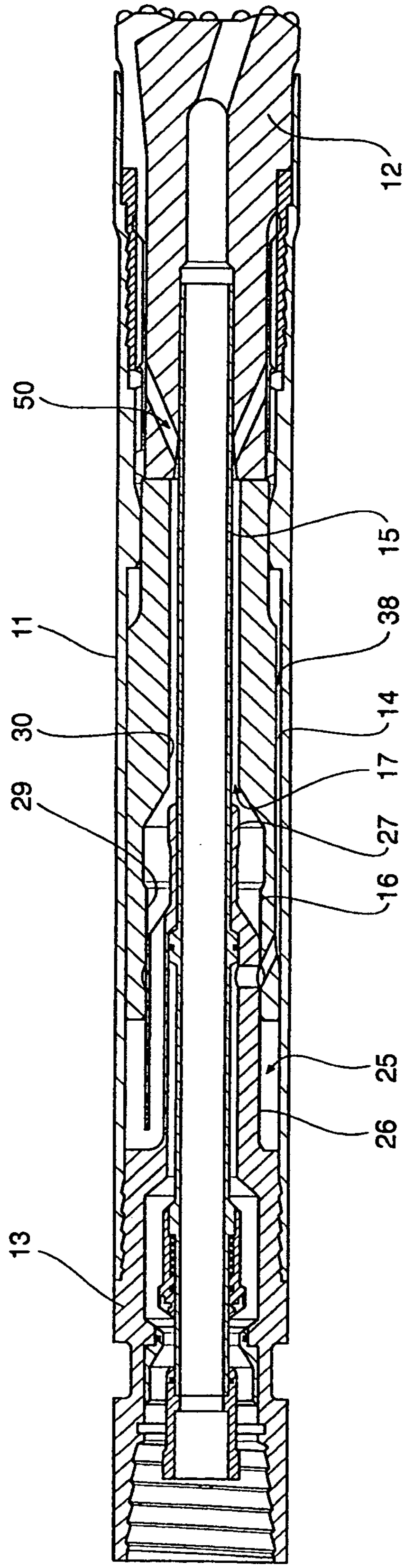

FIG 2

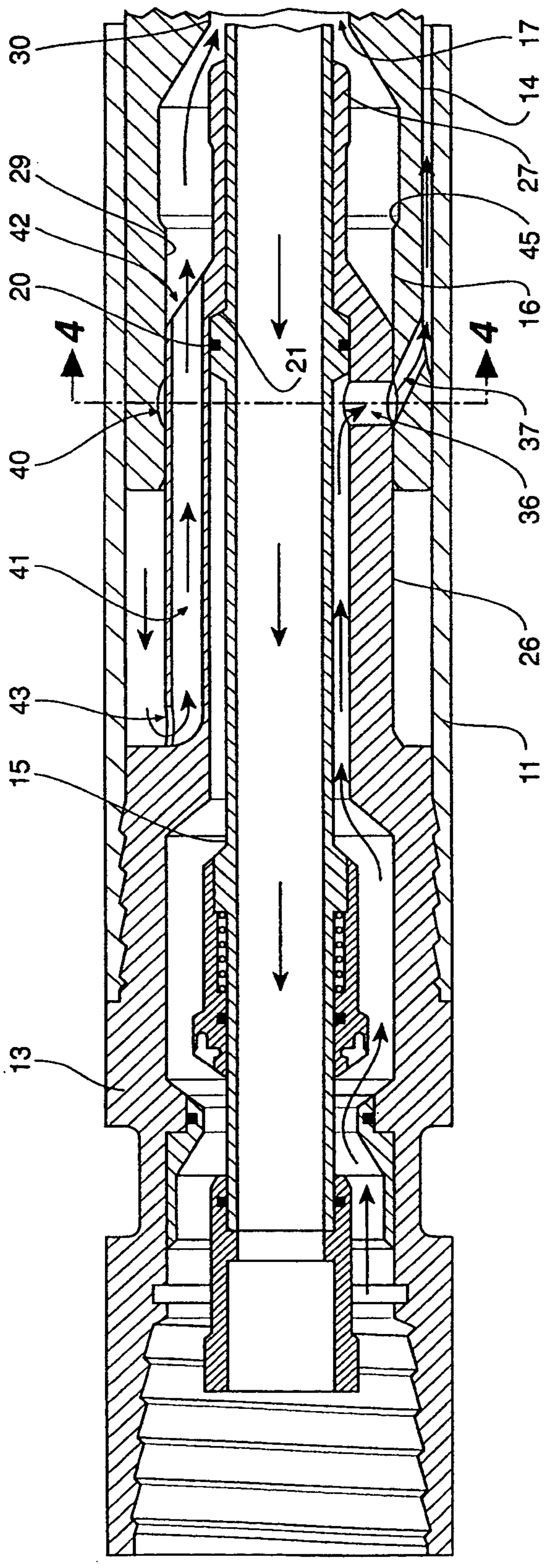

FIG 3

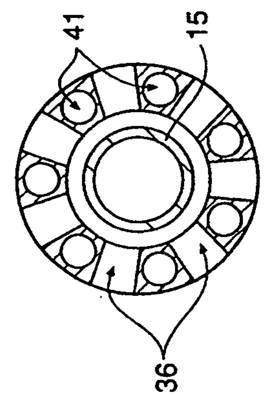

FIG 4

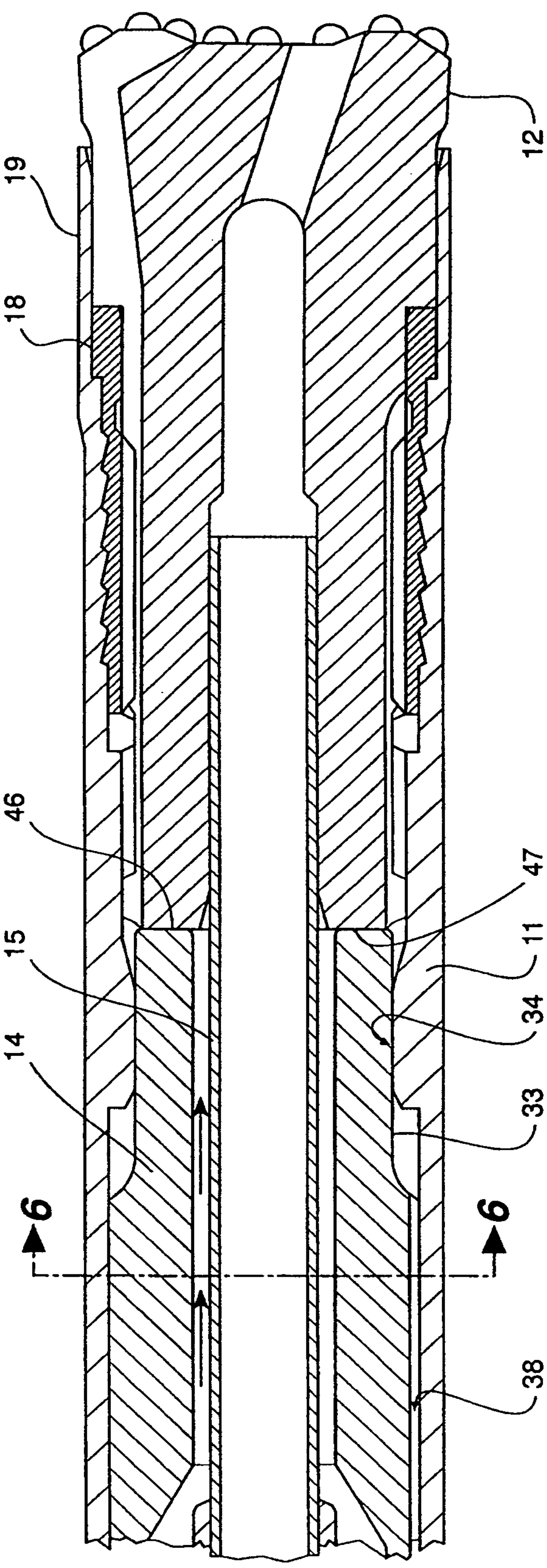

FIG 5

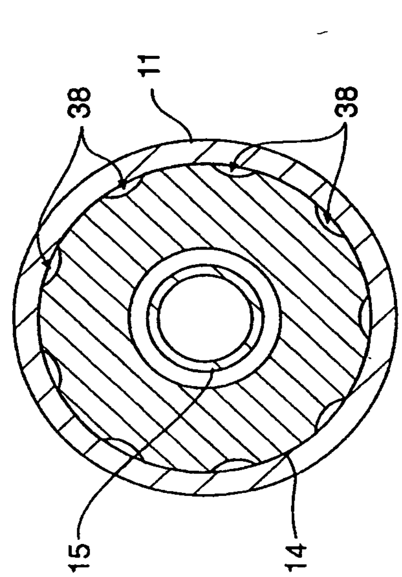

FIG 6

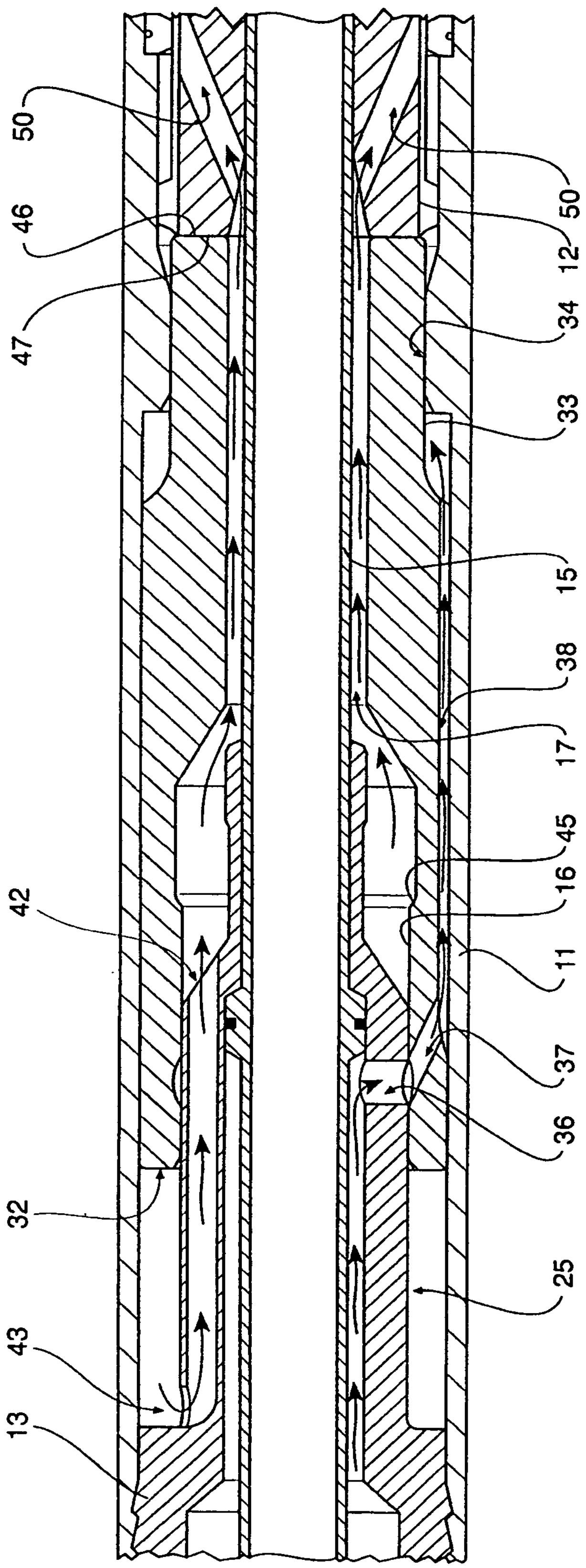

FIG 7

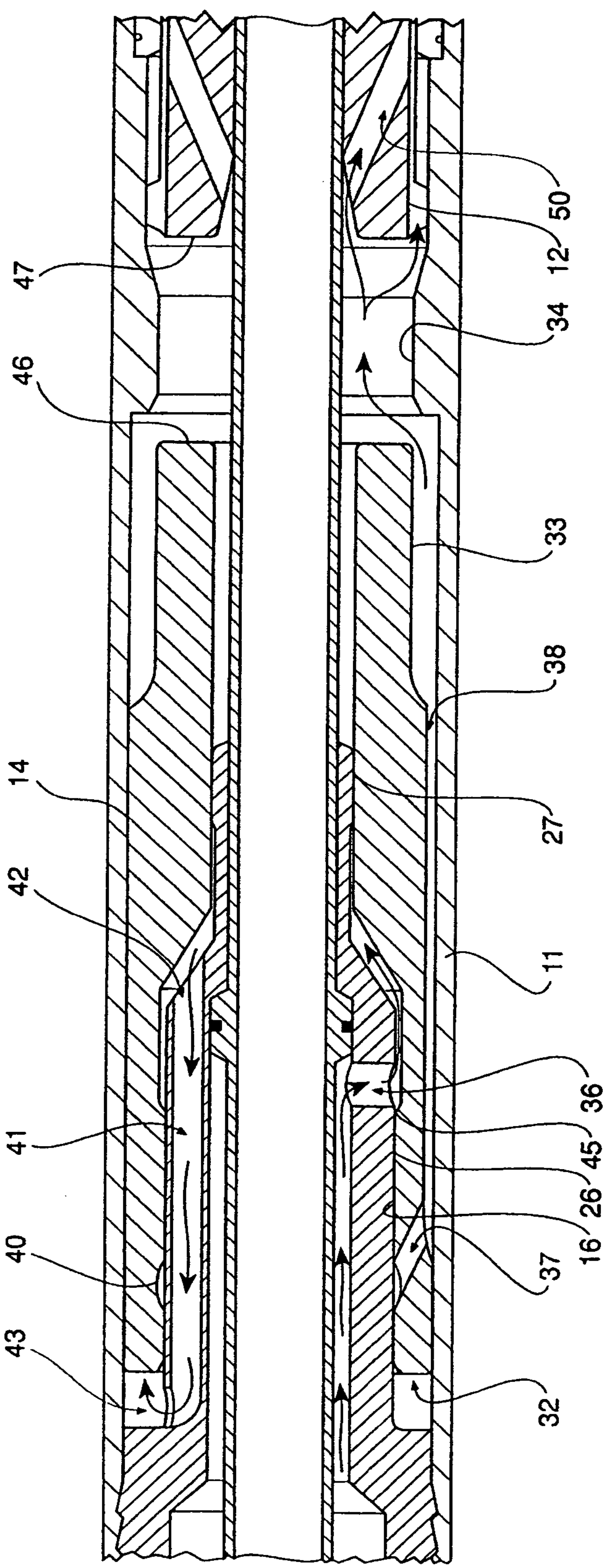

FIG 8

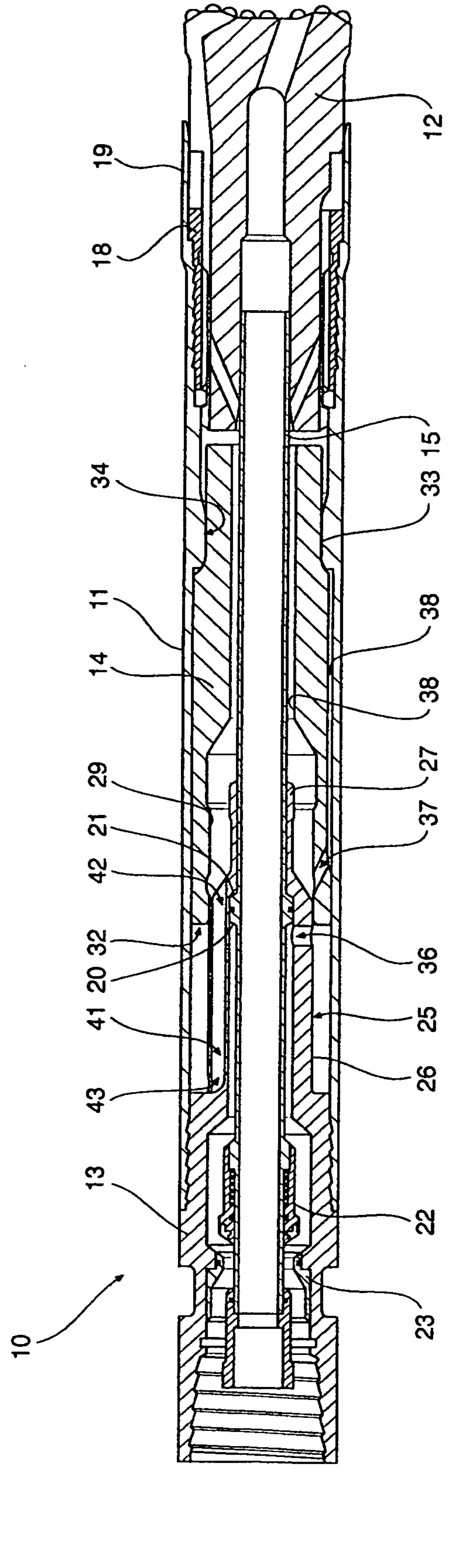
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FIG 9

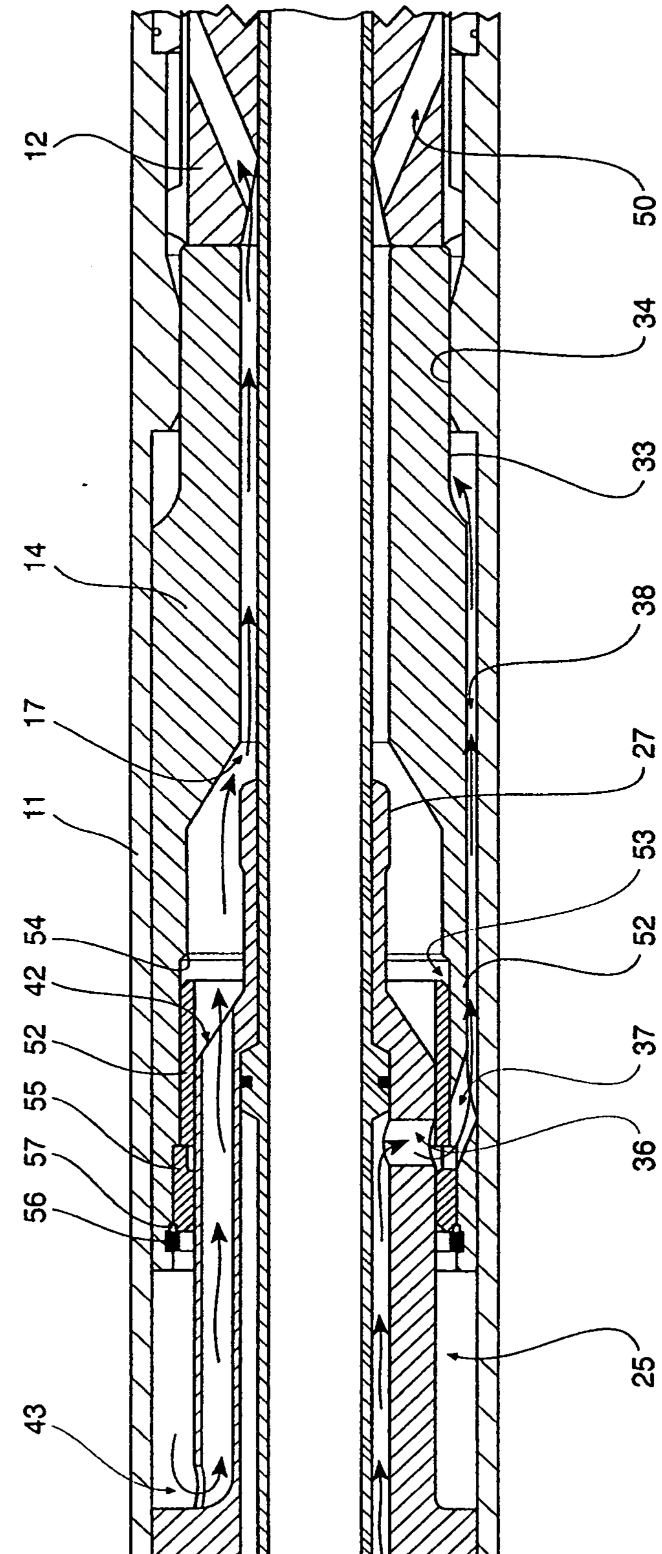

FIG 10

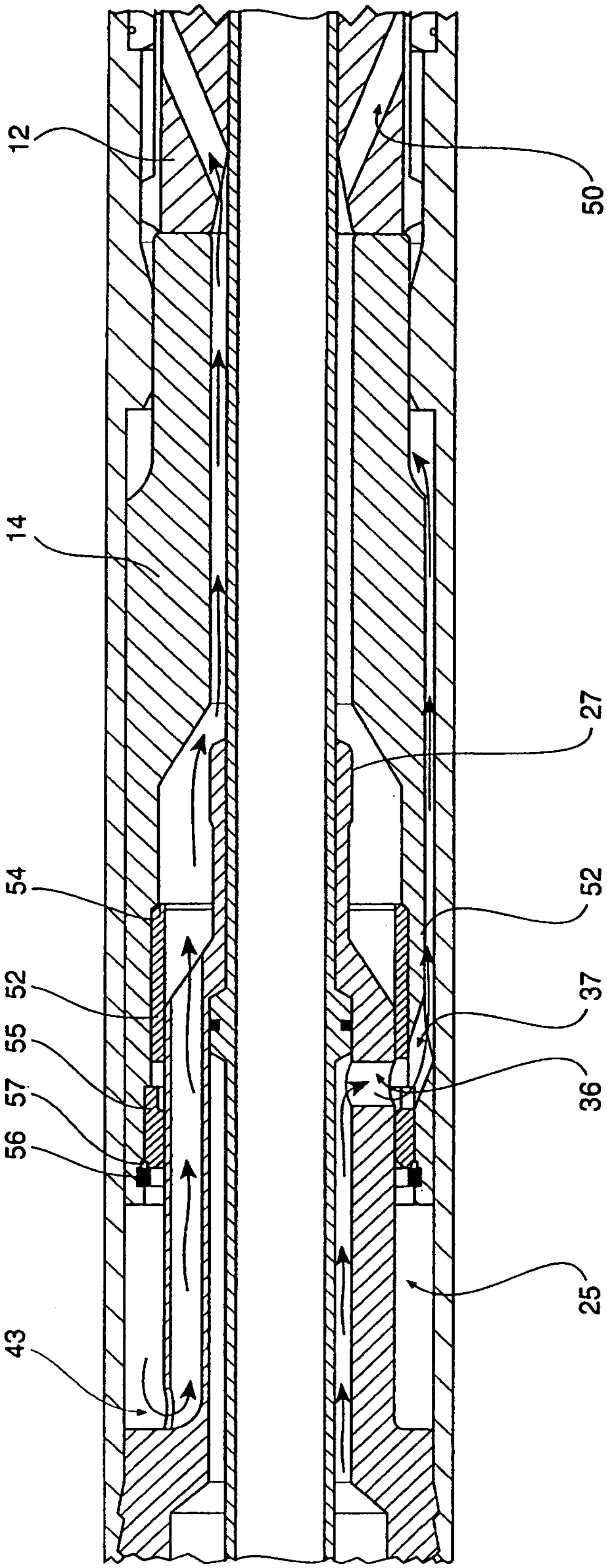

FIG 11

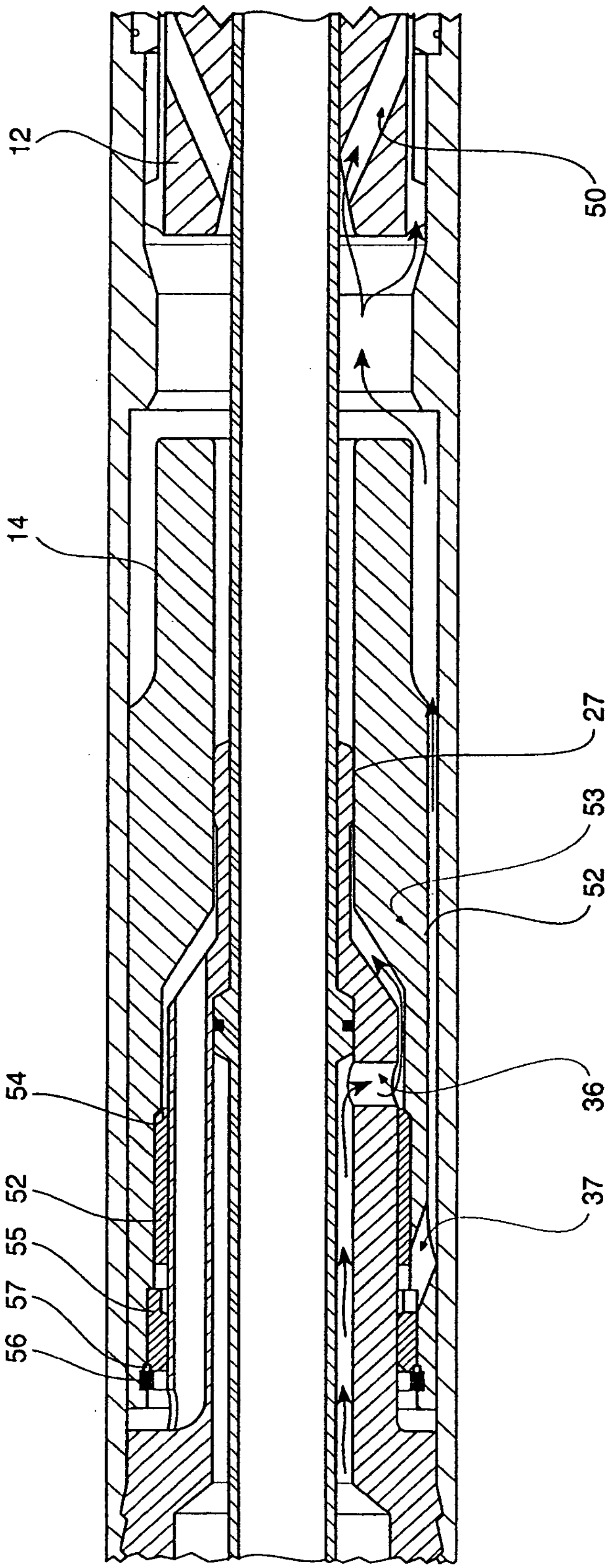

FIG 12

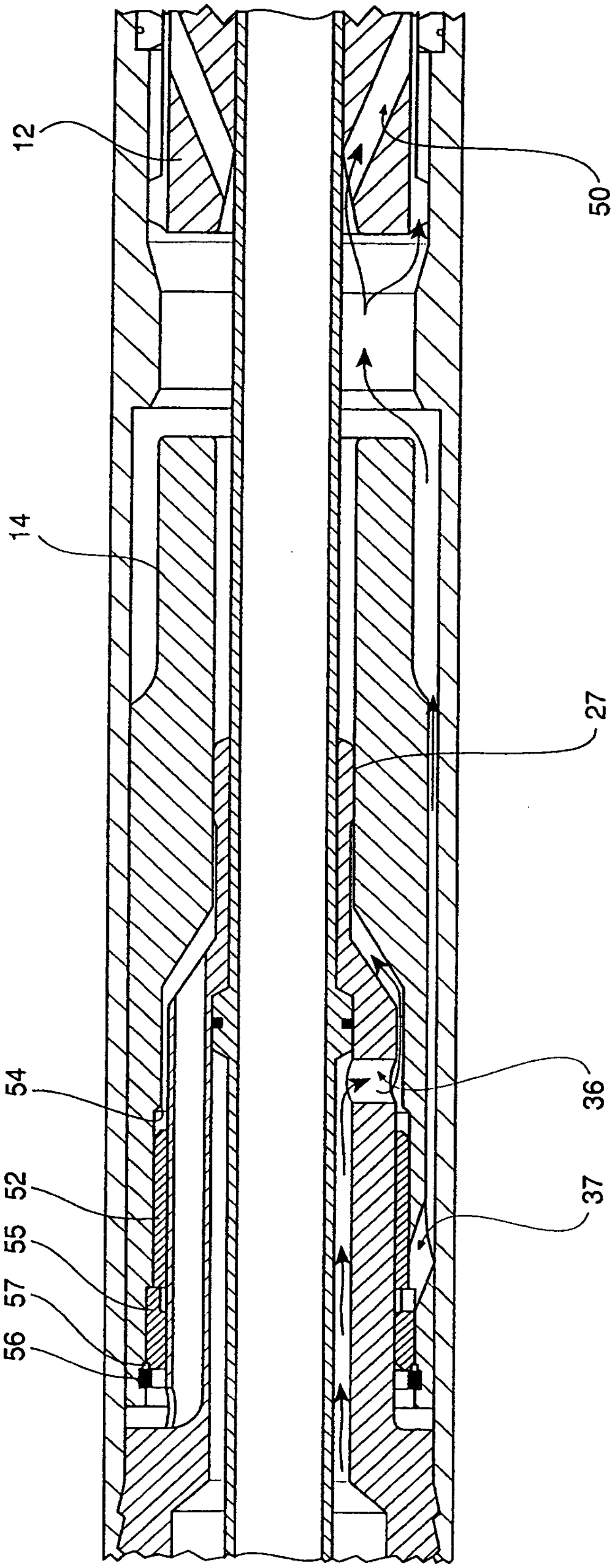

FIG 13

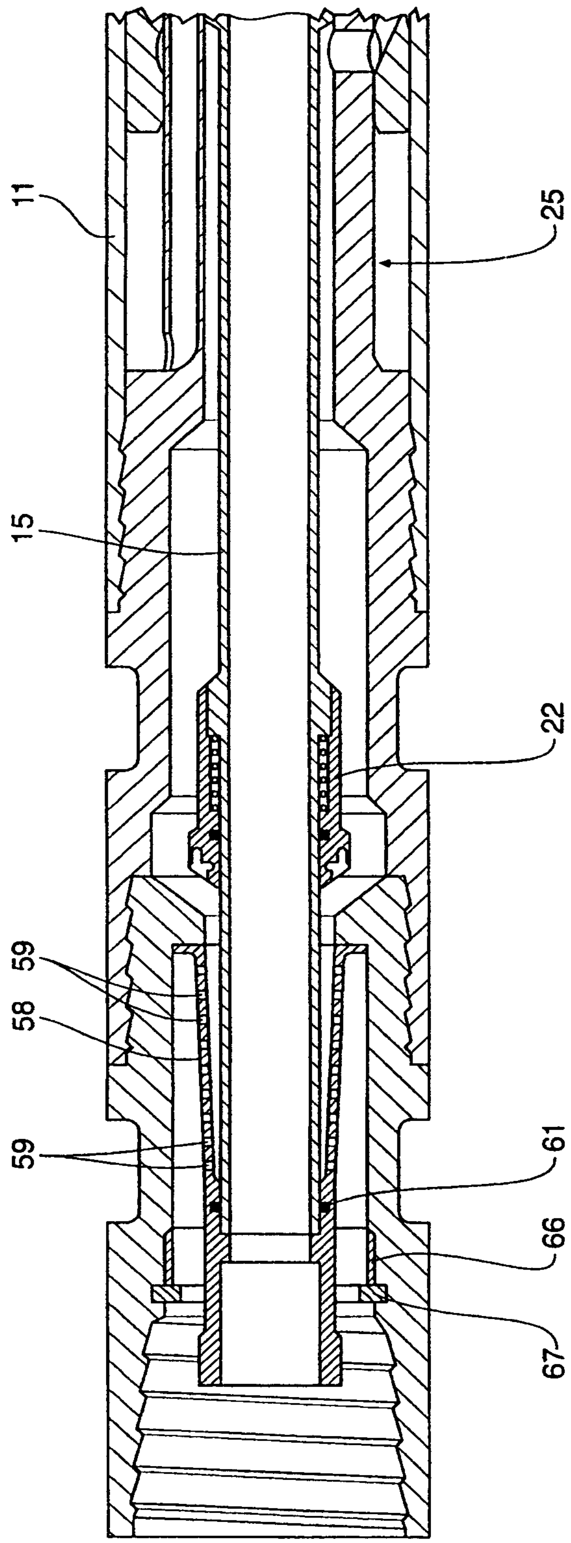

FIG 14

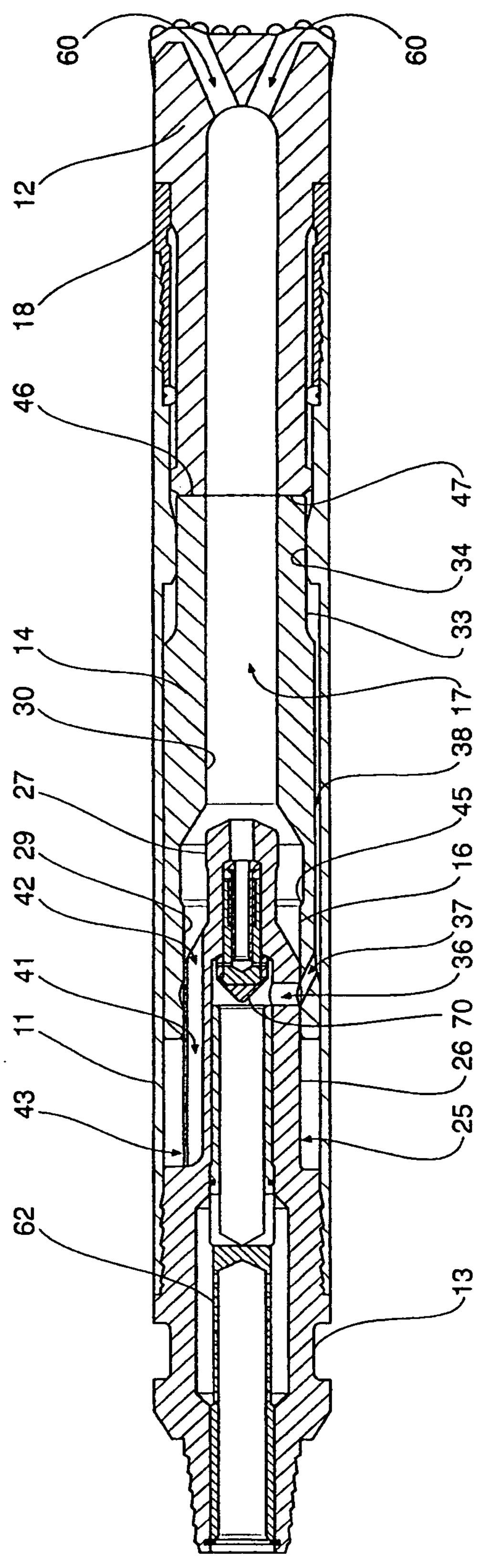
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FIG 15

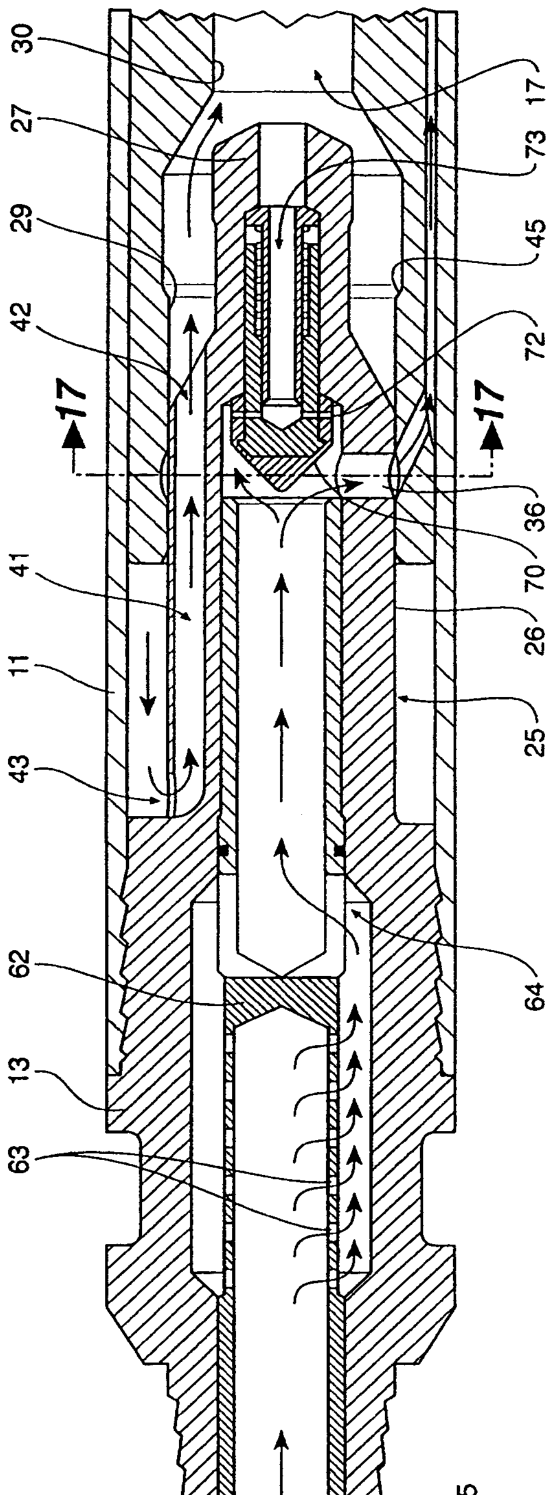

FIG 16

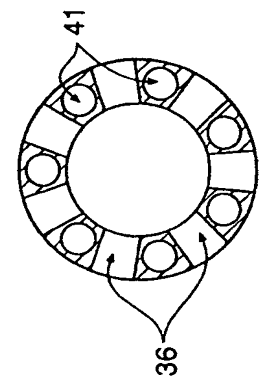

FIG 17

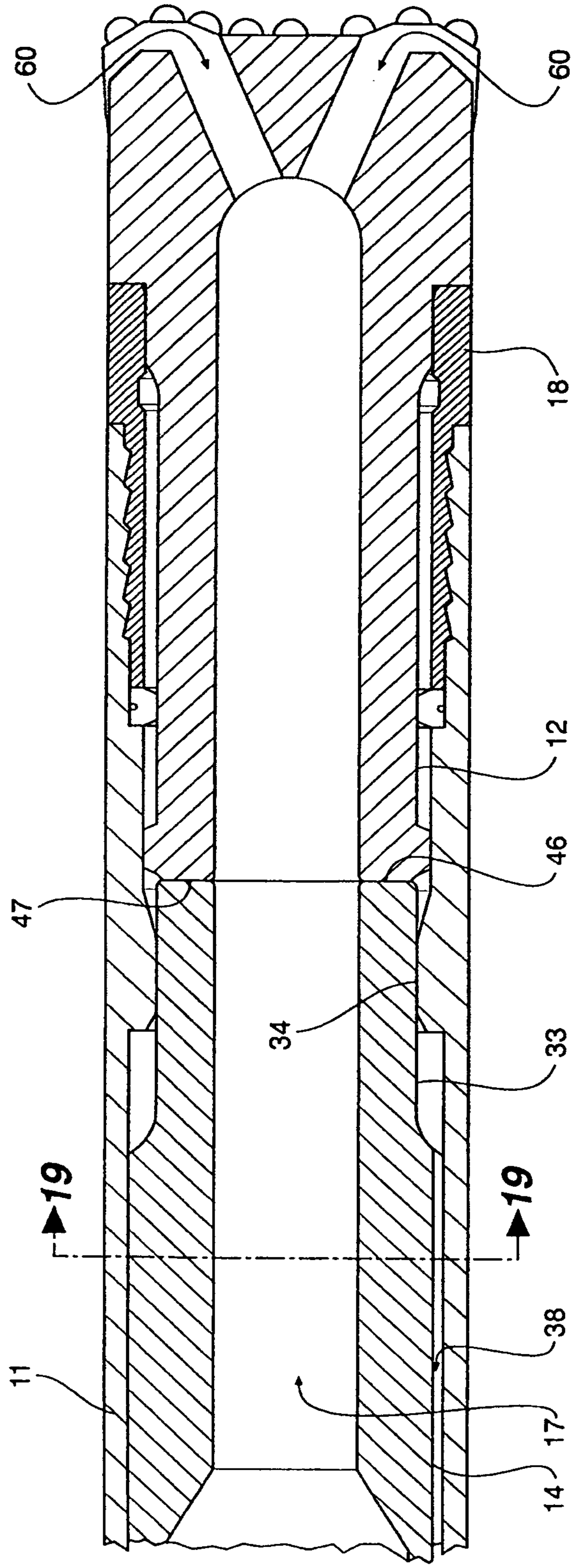

FIG 18

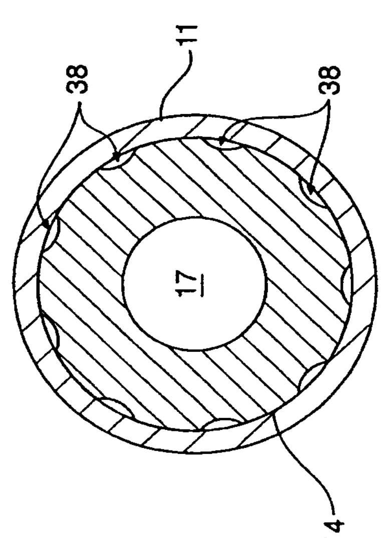

FIG 19

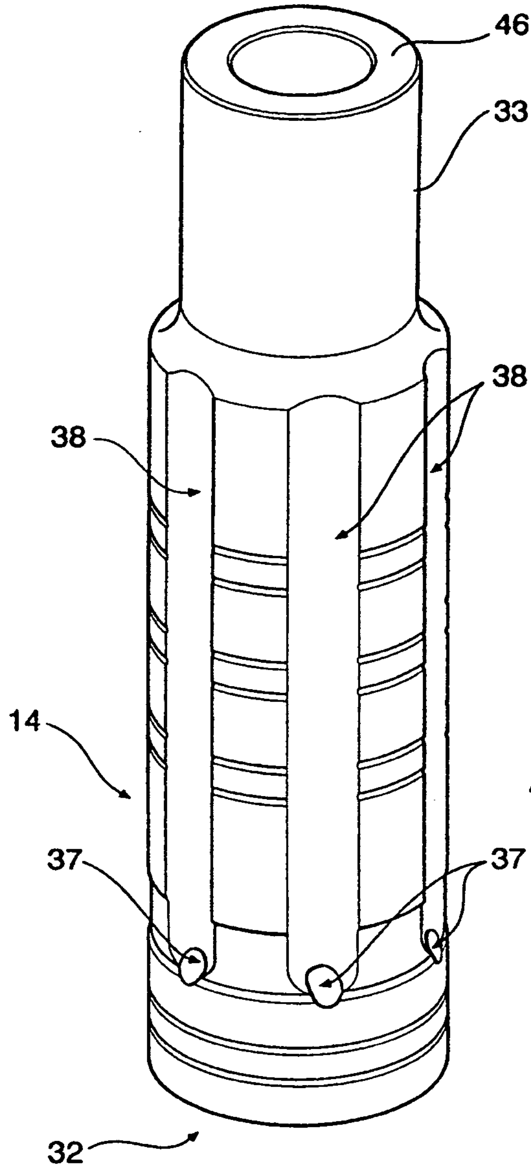

FIG 20

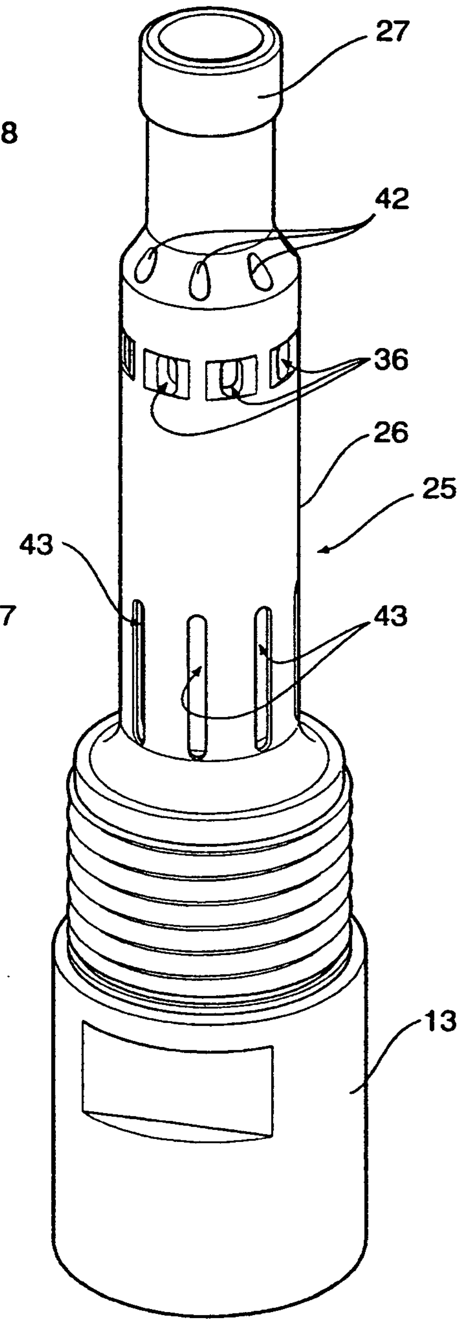

FIG 21

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/AU 98/00384

A. CLASSIFICATION OF SUBJECT MATTER

Int Cl^{6}: E21B 004/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
E21B 004/14

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X — Y	EP 580056 A1 (SMITH INTERNATIONAL, INC.) 26 January 1994 column 2, line 37 - column 4, line 37; column 5, line 40 - column 8, line 50 and figures 1-10	1-3, 5, 6, 12-17 and 21 — 18 and 19
Y	US 4911250 A (LISTER) 27 March 1990 whole document	18 and 19
A	EP 83507 A2 (REAR) 13 July 1983 page 4, line 18 - page 19, line 28 and figures 1-9	1-21

[X] Further documents are listed in the continuation of Box C

[X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 June 1998	-2 JUL 1998

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INTERNATIONAL SEARCH REPORT

International Application No.
PCT/AU 98/00384

C (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4312412 A (PILLOW) 26 January 1982 whole document	1-21
A	US 4446929 A (PILLOW) 8 May 1984 whole document	1-21
A	US 5238073 A (REAR) 24 August 1993 column 2, line 1 - column 5, line 41 and figures 1-5	1-21
A	AU 83504/91 (636057) B (ROCK DRILL TECHNICAL SERVICES LIMITED) 19 March 1992 whole document	1-21
A	AU 40793/95 (682640) B (MINROC TECHNICAL PROMOTIONS LTD.) 18 July 1996 figures 1-4	1-21

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No.
PCT/AU 98/00384

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
EP	580056	AU	41789/93	CA	2099917	NO	932568
		US	5305837	ZA	9304693	US	5322136
US	4911250	AU	81767/87	CA	1295604	EP	327575
		GB	2215757	WO	8803220	ZA	8708007
EP	83507	AU	91761/82	ZA	8300027		
US	4312412	AU	60196/80	CA	1131210	DE	3027393
		ES	494018	ES	8106788	FR	2463255
		GB	2054705	ZA	8004273		
US	4446929	AU	58306/80	CA	1128926	DE	3021474
		ES	492313	ES	8105814	FR	2458668
		GB	2052608	ZA	8002762		
US	5238073	AU	14049/92	CA	2065125	EP	507610
		ZA	9202469				
AU	83504/91	NONE					
AU	40793/96	GB	2296731	IE	950010	ZA	9600030

END OF ANNEX